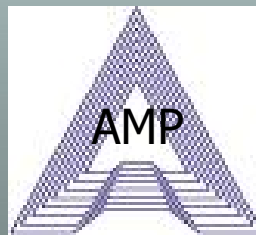


A Proposed Utah Center of Excellence

BULK NANOCRYSTALLINE ULTRAHARD MATERIALS FOR INDUSTRIAL APPLICATIONS



BULK NANOCRYSTALLINE ULTRAHARD MATERIALS FOR INDUSTRIAL APPLICATIONS

A \$1.9 million R&D Program Supported by

Department of Energy: \$1.3 million

Industrial partners: \$600K

Request: \$125,000 per year for five years to

Commercialize in Utah

Outlines

- ❑ Products and technology
an “incremental” nano technology
- ❑ Markets and applications
- ❑ Commercialization strategy

Product and Technology

Industrial bulk nanocrystalline materials

*Specifically, tungsten carbide and other
superhard manufacturing tool materials*

Main market

***Manufacturing tools: auto, aerospace, oil,
mining, construction, ...***

a market that is mature, huge, and stable

Product and Technology

Superior mechanical properties of nanocrystalline tungsten carbide and benefits to manufacturing industries:

- Extremely high hardness / wear resistance, and superior toughness
- Machining: Moderately better tool will bring 3% productivity gain which is \$3.75 billion saving per year in US alone.
- Oil drilling: Rig cost as high as \$30,000 per hour.
5-15 bits per well
Trip time of changing drill bit – 1 to x days.
Reduce number of bits – huge savings!

-Challenges-

Availability of nanoscaled powders raises possibility of superior properties, but sintering at high temperatures causes grain growth and coarsening, - lost nano characteristics.

- *How to prevent coarsening?*
- *How to produce bulk nanocrystalline materials cost effectively?*

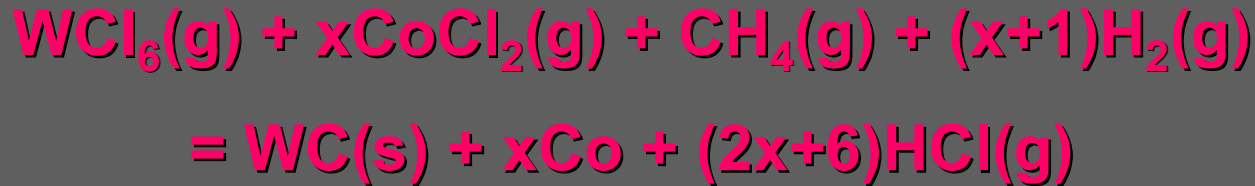
Product and technology

Meet the challenges

- ✓ **Chemical vapor synthesis of nano powder**
- ✓ **Ultrahigh pressure rapid hot consolidation**

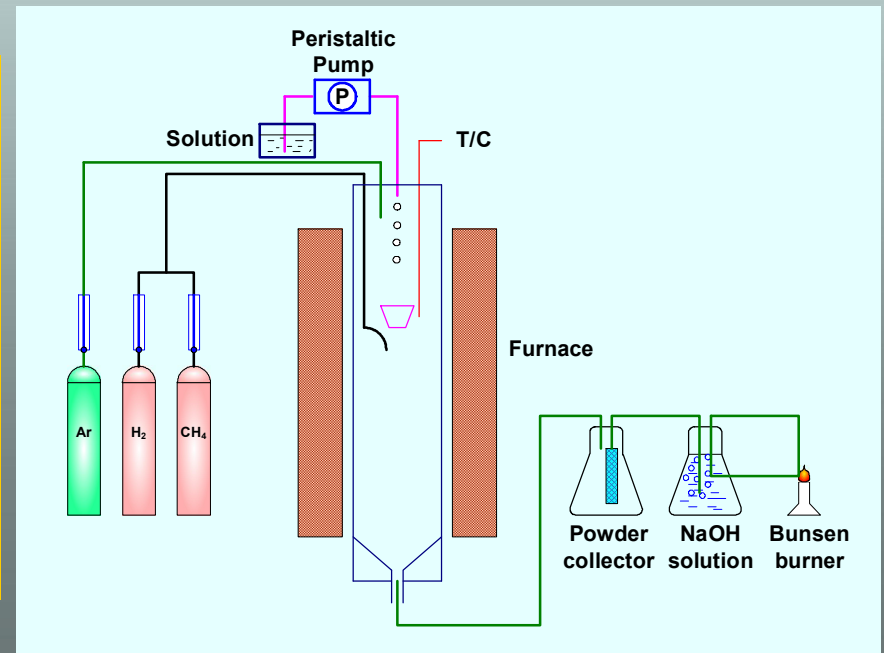
Chemical Vapor Synthesis (CVS)

Chemistry

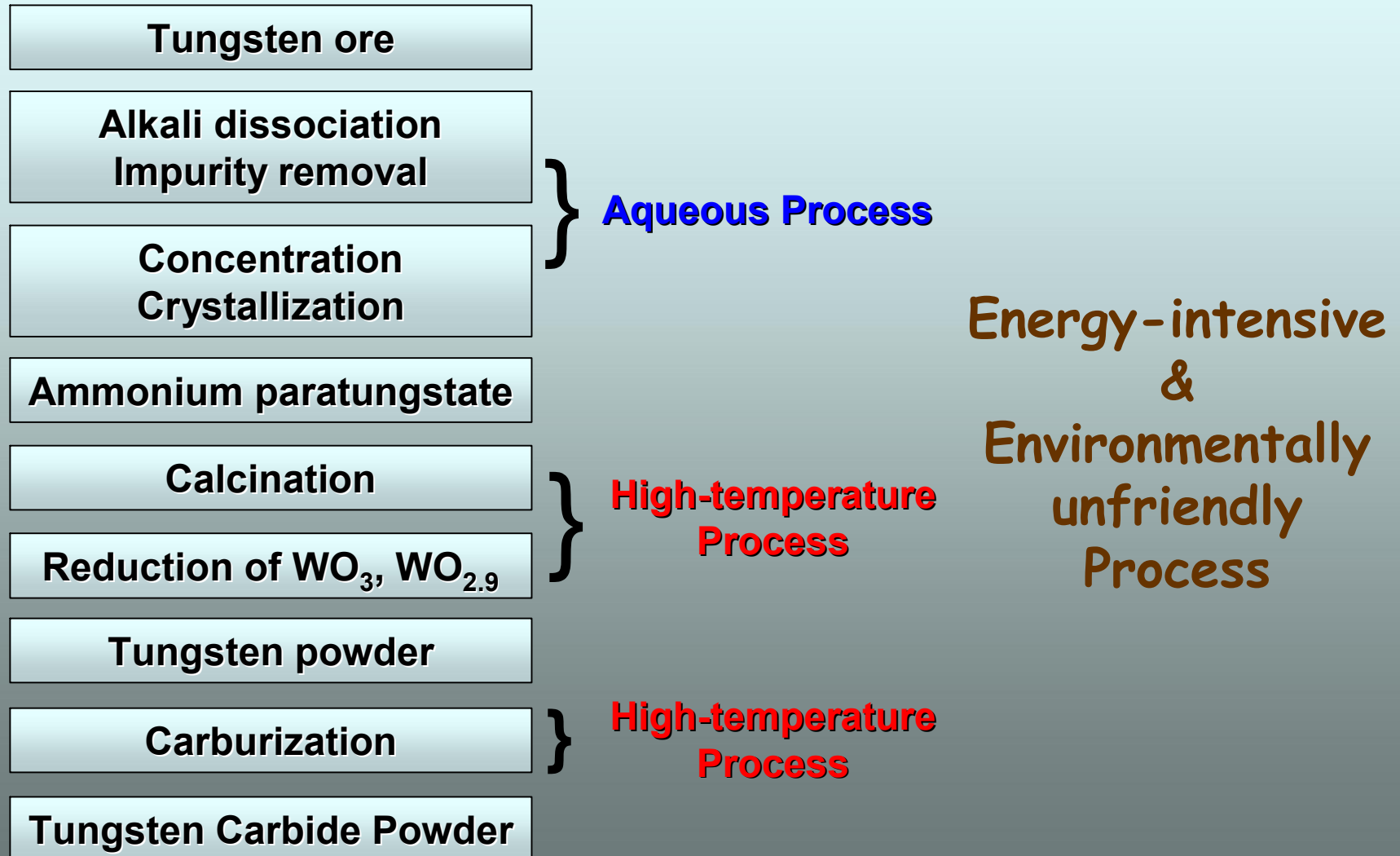


$\Delta G^\circ = - (151+13x) \text{ kcal at } 1200^\circ\text{C}; \Delta H^\circ = - (10.5+20.2x) \text{ kcal}$

- Homogeneity at atomic level
- Flexibility in alloying, doping powder
- Nanopowders with narrow size distribution
- Composite nanopowders



Conventional Method of Making Tungsten Carbide Powder



Product and technology

**Ultrahigh Pressure
Rapid Hot Consolidation**



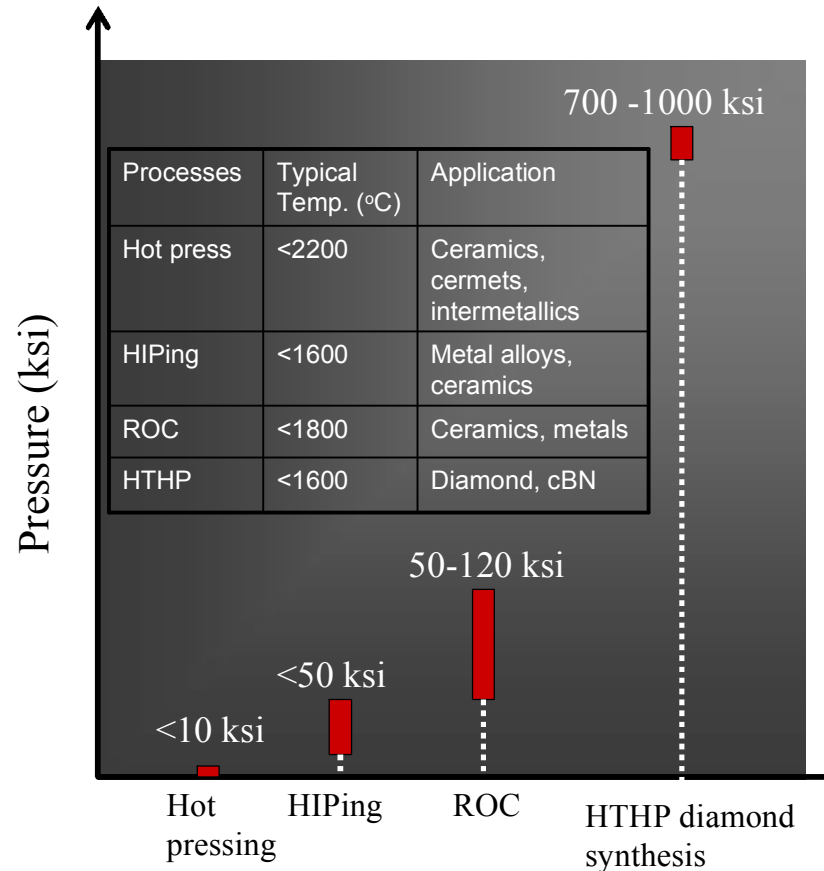
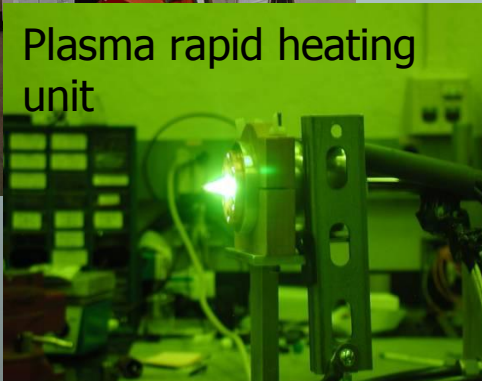
**Manufacturing Bulk
Nanocrystalline Materials**

Ultrahigh Pressure Rapid Heating and Hot Consolidation

- Rapid and energy efficient process.
- A batch process - commercially viable high pressure technology.



Plasma rapid heating unit



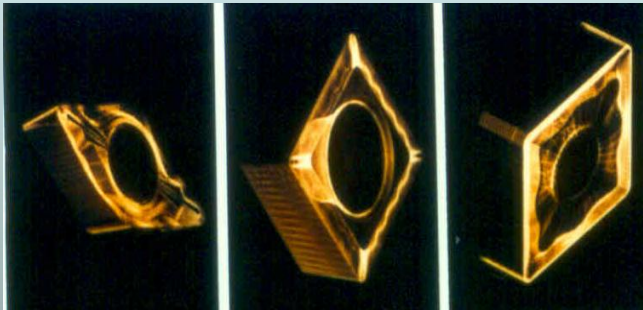
Product and technology

This is an "incremental" (not radical) nano technology that will

- Dramatically improve industrial tools and
- Bring economic benefit in shorter term
- Nano technologies for manufacturing industries are more sustainable

Market and Applications

Metal machining



Electronics manufacturing



Mining and construction



Wear parts

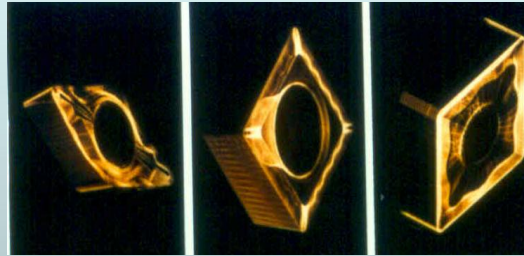


Oil and gas drilling

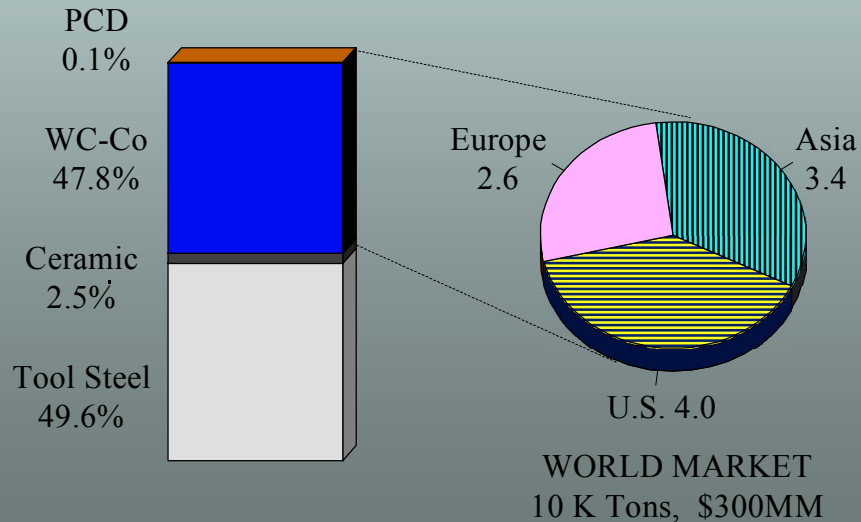


Target Applications and Market

Metal machining



Cutting Tools
K Tons / Yr.



Major Manufacturers

Ceramets S.a.r.l.
Kennametal Inc.
Fansteel Hydro Carbide
Plansee Tizit GmbH
Mitsubishi Materials Corp.
Rogers Tool Works
Boart Longyear Limited

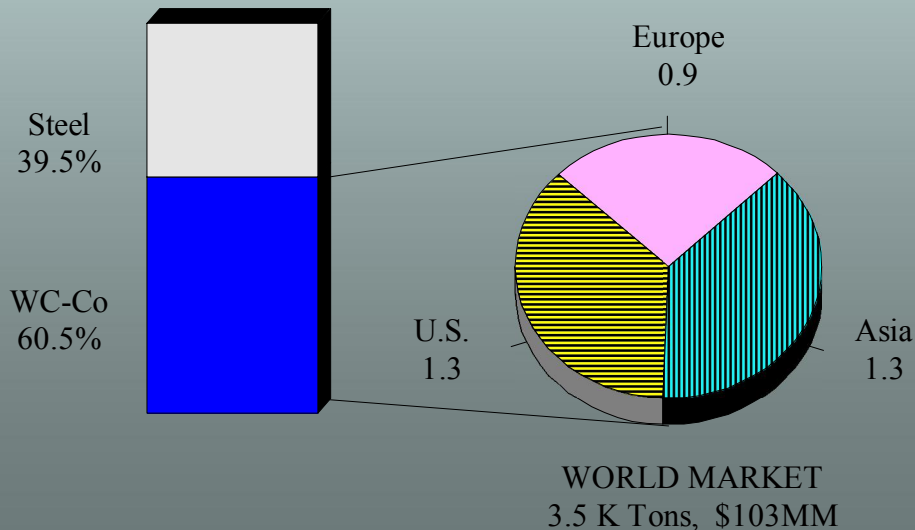
AB Sandvik Hard Materials
Sumitomo Electric Industries, Ltd.
Teledyne Advanced Materials
Toshiba Tungalloy Co. Ltd.
Valenite Inc.
Zhuzhou Cemented Carbide Works
Carmet Inc.

Target Applications and Market

Mining and construction



Mining Tools
K Tons / Yr.



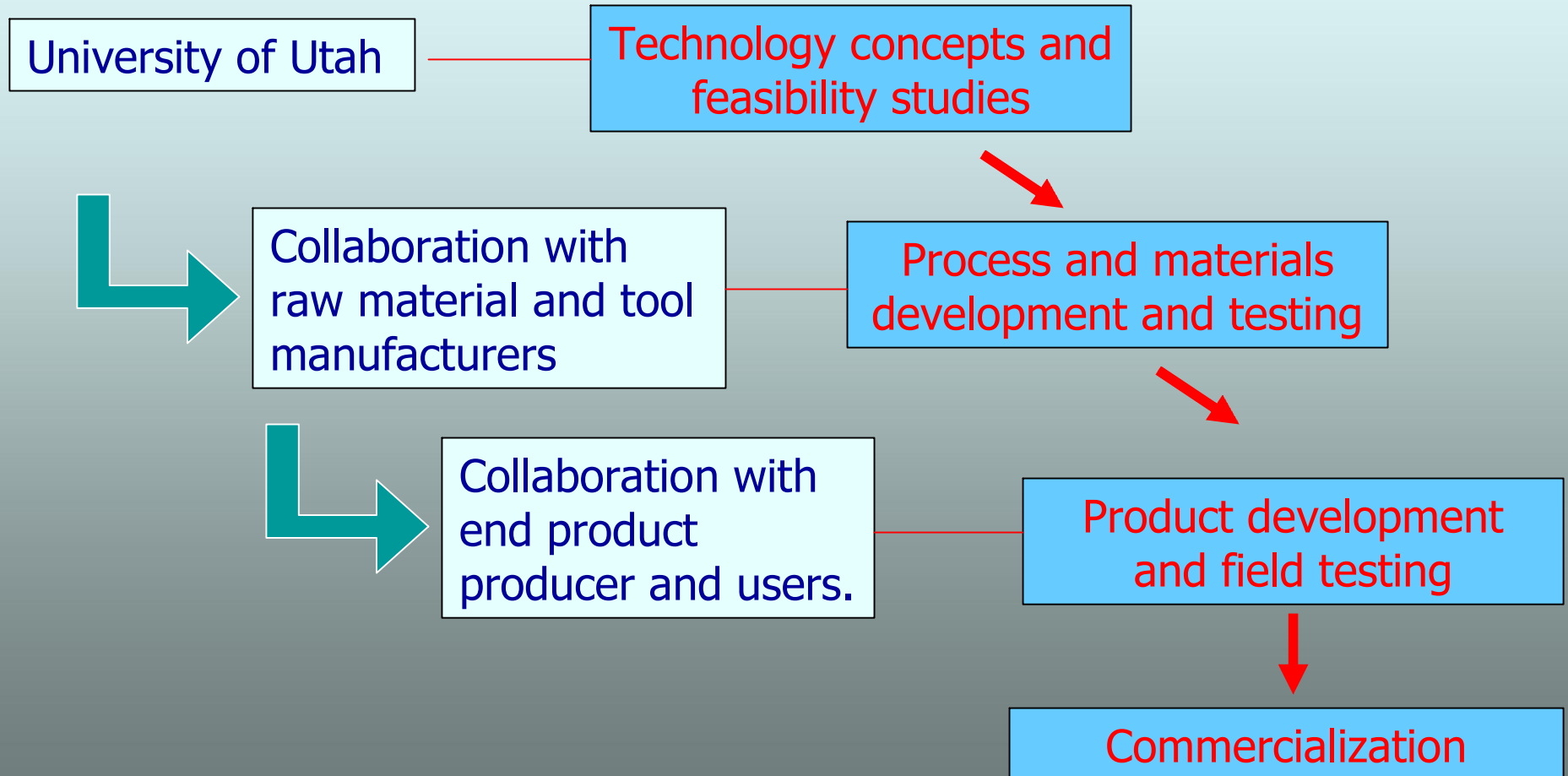
Major Manufacturers

Boart Longyear Limited
Hughes Christianson Company
Kennametal Inc.
Rogers Tool Works
AB Sandvik Hard Materials
Uniroc AB

Marketing Strategy

- Leverage collaboration with industrial partners, especially end users
- Initial market penetration through the partners.
- Local industry to manufacture advanced and cutting edge products.
- A field-of-use based licensing strategy

Commercialization Path



Commercialization Timeframe

<i>Products / services</i>	<i>Initial test products for customer evaluations</i>	<i>Initial commercial products offering</i>	<i>Scale-up for pilot productions</i>
Nancoscaled WC/Co powder	End of 21 months	3 rd quarter of year 3	1 st quarter of year 5
Sintered products of nanocrystalline WC-Co	End of year two	End of year three	2 nd quarter of year 5
Toll services using UPRH	End of year one	End of year two	End of year three

Financial Projections*

	Products / Services	3rd year	4 th year	5 th year
Revenues	Nanoscaled powders	\$6.0 million	\$6.6million	\$7.26million
	Sintered nano products	\$10.0 million	\$11.0million	\$12.1million
	Toll services (UPRH)	\$500K	\$550K	\$605K
Expenses		\$11.55 million	\$12.7million	\$13.98million
Income (EBIT)*		\$4.95million	\$5.45million	\$5.98million

*Assuming a 10% annual growth and 30% margin, business outcome in 3-5 years after the technology is ready.

Management and Technical Team

Professor

Z. Zak Fang University of Utah
10 years industrial R&D Director,
Product development experience
30 US patents. A few commercialized.

Professor

H. Y. Sohn University of Utah
30 years of world renowned excellence
8 prestigious science & technical awards

Dr.

Peter Kong Idaho National Lab
Technical Lead, Plasma processing

Mr.

Scott Packer, President, Advanced Metal Products,
Utah Small Business Entrepreneur

Dr.

Shivanand Majagi Director, R&D,
AMSG, Kennametal Inc.,

Dr.

Anthony Griffo Manager,
Materials R&D, Smith International

Thank You!